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(54) Title: METHOD AND QUERY OPTIMIZATION SERVER FOR ASSOCIATING FUNCTIONS WITH COLUMNS FOR OPTIMIZING QUERY EXECUTION

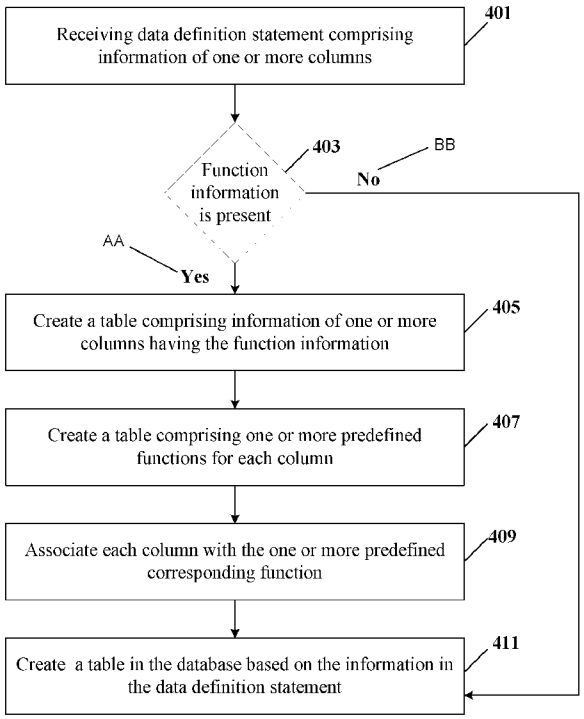

Fig.4a

(57) Abstract: The present disclosure relate to a method of optimizing query execution by associating functions with columns. The method comprises receiving, by a query optimization server, data definition statement comprising information of one or more columns and function information for each of the one or more columns. The query optimization server associates the columns having the function information with corresponding predefined functions and stores in a memory. Upon receiving a query comprising a function associated to a column, the query optimization server compares the function with predefined functions stored in the memory. The query optimization server accesses the predefined function from the memory for executing the query based on the comparison.

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METHOD AND QUERY OPTIMIZATION SERVER FOR ASSOCIATING FUNCTIONS WITH COLUMNS FOR OPTIMIZING QUERY EXECUTION

TECHNICAL FIELD

The present disclosure relates generally to database management systems and, in particular, to a system and method for optimizing query execution by associating functions with columns.

BACKGROUND

Generally, data in a database is accessed using queries. A query is a statement in a particular syntax that specifies the data to be retrieved from the database. A query processor typically processes the query, identifies the best plan for executing the query and retrieves data from the database that matches the parameters specified in the query. One example of the database query and programming language is Structured Query Language (SQL), which is used to store, retrieve and query the data stored in the relational database system.

Presently, queries associated with the mathematical functions like average, sum, max, min, etc. are executed by invoking a function manager at run time. The function manager provides a respective mathematical function like average function, sum function, maximum function, and minimum function during the run time execution of the query as per the column data type defined in the query. Consider the below query examples:

CREATE TABLE test (a int, b int, c varchar) ---------- (1)
SELECT AVG (a) FROM test WHERE b > 100 ---------- (2)

Upon execution of the “Create” query, a table is created in the database with three columns namely column a, column b and column c. For executing the “Select” query, the function manager determines during the runtime that the column type “a” is an integer, and therefore an integer average (Avg) function has to be invoked for executing the query. This

creates an extra overhead on the execution process to invoke the respective mathematical function using the function manager, which in turn affects performance of the query execution.

To overcome the above mentioned problem, the functions are predefined and stored, so that they can be accessed directly during the runtime. But, there are numerous mathematical functions and also numbers of columns for a table would be enormous. Therefore, it is difficult to precompile and predefine all the possible combinations of the functions.

SUMMARY

The objective of the present disclosure is to optimize the query execution by predefining functions and by accessing the functions, which are associated with the columns provided in the query, directly at run time execution.

The present disclosure relates to a method of associating functions with columns for optimizing query execution. The method comprises receiving a definition statement comprising information of one or more columns for creating a table by a query optimization server. Upon receiving the definition statement, the query optimization server determines the presence of one or more function information for each of the one or more columns in the definition statement. If the one or more function information is provided in the definition statement, the query optimization server associates each of the one or more columns having the one or more function information with corresponding predefined functions for optimizing the query execution.

In an embodiment, the present disclosure provides a method for receiving a query statement by the query optimization server. The query statement comprises one or more functions associated with one or more columns, for querying a database. Upon receiving the query statement, the query optimization server compares the one or more functions associated with the one or more columns with predefined functions associated to the one or more columns in the memory. The query optimization server accesses the predefined function associated to the one or more columns from the memory based on the comparison for executing the query statement.

The present disclosure provides a query optimization server for optimizing query execution by associating functions with columns. The query optimization server comprises a receiving module, determination module and association module. The receiving module receives

a definition statement comprising information of one or more columns for creating a table from one or more client devices. The receiving module also receives a query statement for querying the database. The determination module determines the presence of one or more function information for each of the one or more columns in the definition statement after receiving the definition statement. The association module associates each of the one or more columns having the one or more function information with corresponding predefined functions for optimizing the query execution.

In an embodiment, the query optimization server comprises a comparison module and accessing module. The comparison module compares the one or more functions associated with the one or more columns with predefined functions associated to the one or more columns in the memory. The accessing module accesses the predefined function associated with the one or more columns from the memory based on the comparison, for execution of the one or more query statements.

The present disclosure relates to a non-transitory computer readable medium including operations stored thereon that when processed by at least one processor cause a query optimization server to perform the steps of receiving a definition statement comprising information of one or more columns for creating a table. The method further comprises determining presence of one or more function information for each of the one or more columns in the definition statement. Upon determining the presence of the function information, the query optimization associates each of the one or more columns having the one or more function information with corresponding predefined functions, for optimizing the query execution.

In an embodiment, the instructions further cause the at least one processing unit to perform one or more actions by performing the acts of receiving a query statement comprising one or more functions associated with one or more columns, for querying a database. Then the act of comparing the one or more functions associated with the one or more columns with predefined functions associated to the one or more columns in the memory is performed. Finally the predefined function with the one or more columns is accessed from the memory based on the comparison for execution of the query statement.

The present disclosure relates to a computer program for performing one or more actions on a query processing system. The said computer program comprising code segment for code segment for receiving a definition statement comprising information of one or more columns for creating a table, code segment for determining presence of one or more function information for each of the one or more columns in the definition statement and code segment for associating each of the one or more columns having the one or more function information with corresponding predefined functions, for optimizing the query execution.

In an embodiment, the present disclosure provides a method for associating functions with columns defined in the data definition statement. The user can provide one or more function information for each column in the data definition statement. Based on the one or more function information, the corresponding predefined functions are associated with the columns and stored in the memory. When a query statement is received which comprises the function associated with columns, the corresponding function is directly accessed from the memory. Therefore, there is no requirement for invoking the function manager for executing the query statement. This improves the query execution performance. Further, the one or more predefined functions are stored in the memory based on the function information in the data definition statement. This reduces the computing resources as there is no need to predefine all the functions in the memory.

The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects and features described above, further aspects, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features and characteristic of the present disclosure are set forth in the appended claims. The embodiments of the present disclosure itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings. One or more embodiments are now described, by way of example only, with reference to the accompanying drawings.

Figure 1 shows exemplary network architecture for optimizing query execution by associating functions with columns in accordance with some embodiments of the present disclosure;

Figure 2a shows a block diagram illustrating a query optimization server with processor and memory for optimizing query execution in accordance with some embodiments of the present disclosure;

Figure 2b shows a detailed block diagram illustrating a query optimization server for optimizing query execution by associating functions with columns in accordance with some embodiments of the present disclosure;

Figures 3a-3b shows an exemplary block diagram illustrating a method for optimizing query execution by associating functions with columns in accordance with some embodiments of the present disclosure;

Figure 4a illustrates a flowchart showing method for associating functions with columns in accordance with some embodiments of the present disclosure;

Figure 4b illustrates a flowchart showing method for accessing functions directly during run-time in accordance with some embodiments of the present disclosure; and

Figure 5 illustrates a block diagram of an exemplary computer system for implementing embodiments consistent with the present disclosure.

The figures depict embodiments of the present disclosure for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles of the present disclosure described herein.

DETAILED DESCRIPTION

The foregoing has broadly outlined the features and technical advantages of the present disclosure in order that the detailed description of the present disclosure that follows may be better understood. Additional features and advantages of the present disclosure will be described

hereinafter which form the subject of the claims of the disclosure. It should be appreciated by those skilled in the art that the conception and specific aspect disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present disclosure. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the scope of the disclosure as set forth in the appended claims. The novel features which are believed to be characteristic of the disclosure, both as to its organization and method of operation, together with further objects and advantages will be better understood from the following description when considered in connection with the accompanying figures. It is to be expressly understood, however, that each of the figures is provided for the purpose of illustration and description only and is not intended as a definition of the limits of the present disclosure.

Embodiments of the present disclosure relate to a method and a query optimization server for optimizing query execution by associating functions with columns. A user provides a definition statement comprising information of one or more columns for creating a table in a database. A query optimization server receives the definition statement, executes the definition statement and creates the table in the database using the information of the one or more columns. The query optimization server further determines the presence of one or more function information for each of the one or more columns in the definition statement. The one or more function information is defined by the user in the definition statement. As an example, the function information comprises mathematical functions like average (avg), maximum (max), minimum (min), sum etc. If the function information is present in the definition statement, then the query optimization server associates the one or more columns having the function information with corresponding predefined functions. The information about each of the one or more columns and the corresponding predefined functions are stored in a memory. Consequently, the query optimization server receives a query statement comprising one or more functions associated with one or more columns, for querying a database. Upon receiving the query statement, the query optimization server compares the one or more functions associated with the one or more columns with predefined functions associated to the one or more columns. If the one or more functions associated with the one or more columns matches with the predefined functions, the query optimization server accesses the predefined functions from the memory for executing the query statement.

Henceforth, embodiments of the present disclosure are explained with the help of exemplary diagrams and one or more examples. However, such exemplary diagrams and examples are provided for the illustration purpose for better understanding of the present disclosure and should not be construed as limitation on scope of the present disclosure.

Figure 1 shows exemplary network architecture for optimizing query execution by associating functions with columns in accordance with some embodiments of the present disclosure.

As shown in **figure 1**, the network architecture **100** comprises a query optimization server **105** for optimizing query execution by associating functions with columns. The architecture **100** also comprises one or more user devices $\mathbf{101}_1$, $\mathbf{101}_2$,...$\mathbf{101}_N$ (collectively referred to as user devices **101**) and a database **107** connected to the query optimization server **105**. As shown in the **figure 1**, such user devices **101** are communicatively coupled to a query optimization server **105** through a communication network **103** for facilitating accessing the database **107** for information.

The user devices **101** comprise an application program that uses the services of the query optimization server **105**. The user devices **101** with the application program may be implemented in a variety of computing systems, such as a laptop computer, a desktop computer, a notebook, a workstation, a mainframe computer, a server, a network server, and the like. The user devices **101** may be used by various stakeholders or end users of the organization, such as project managers, executives and employees. In an embodiment, the user devices **101** are used by associated users to create one or more queries. The user devices **101** are installed with one or more interfaces (not shown in **figure 1**) for communicating with the query optimization server **105** over the network **103**. In an embodiment, the query optimization server **105** can act as user device **101**. Therefore, the one or more queries are directly received at the query optimization server **105** for query execution and user interaction.

The database **107** stores information of one or more establishments in a predefined format or structures or extensions, such as but are not limiting to, a flat file, a hierarchical on-line analytical processing data cube, a multidimensional cubes, a relational data store, an on-line

analytical processing (OLAP) data cube and an Excel file. A person skilled in the art should understand that there can be any number of databases that stores information.

Figure 2a shows an exemplary block diagram illustrating a query optimization server with processor and memory for optimizing query execution by associating functions with columns in accordance with some embodiments of the present disclosure.

The query optimization server **105** comprises an interface **201**, a memory **203** and a processor **205**. The interface **201** is coupled with the processor **205** through which data are received from the one or more user devices **101**. The memory **203** is communicatively coupled to the processor **205**. The memory **203** stores processor-executable instructions which on execution cause the processor **205** to perform one or more steps. In an embodiment, the processor **205** receives one or more definition statements from the one or more user devices **101**. The one or more definition statements include information about one or more columns for creating one or more tables in the database **107**. The tables organize the information into rows and columns. The definition statements also include one or more function information for each column. The function information comprises mathematical functions associated with the columns. The processor **205** associates the columns with corresponding predefined functions based on the function information. The predefined functions are the precompiled mathematical functions based on the function information. The predefined functions are stored in the memory **203**. The processor **205** may also receive one or more query statements from the one or more user devices **101**. The one or more query statements may include one or more functions associated with one or more columns. The processor **205** compares the one or more functions associated with the one or more columns with the predefined functions associated to one or more columns. If the one or more functions matches with the predefined functions, the processor **205** accesses the predefined function for executing the query statement.

Figure 2b shows a detailed block diagram illustrating a query optimization server for optimizing query execution by associating functions with columns in accordance with some embodiments of the present disclosure.

In an embodiment, the query optimization server **105** receives data from one or more user devices **101.** In one example, the data may be stored within the memory **203**. In one implementation, the data may include column data and function data.

In an embodiment, the column data may include information of one or more columns for creating the table in the database **107**.

In an embodiment, the function data may include information of one or more functions for each of the one or more columns. As an example, the function may include, but not limited to, a mathematical function like average, sum, minimum, aggregate and maximum. A person skilled in the art should understand that any other functions which involve invoking the function manager can be used in the present disclosure.

The memory **203** may also include other data which may comprise temporary data and temporary files, generated by the modules for performing the various functions of the query optimization server.

In one embodiment, the data may be stored in the memory **203** in the form of various data structures. Additionally, the aforementioned data may be organized using data models, such as relational or hierarchical data models. In an embodiment, the data are processed by modules of the query optimization server **105**.

In an embodiment, the data received from the one or more user devices **101** are processed by modules of the query optimization server **105**. The modules may be stored within the memory **203**. As used herein, the term module refers to an application specific integrated circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group) and memory **203** that execute one or more software or firmware programs, a combinational logic circuit, and/or other suitable components that provide the described functionality.

The modules may include, for example, a receiving module **207**, a determination module **209**, an association module **211**, a comparison module **213**, accessing module **215** and other module **217**. In an embodiment, the modules may perform the described functions independently or as a part of the processor **205**.

In an embodiment, the receiving module **207** is configured to receive the data definition statement and the data query statement from the one or more user devices **101**. The data definition statements include information about one or more columns for creating a table in the database **107**. The data definition statement also includes one or more function information associated with the one or more columns. In an embodiment, the information about one or more functions is provided as "HINT" in the data definition statement. As an example, a data definition statement is as given below in equation (3). The below data definition statement is for creating a table namely "test". The number of columns defined in the below data definition statement are three namely "col a", "col b" and "col c". The mathematical functions average (avg) and sum are associated with "col a" and the mathematical function (max) is associated with the "col b".

CREATE TABLE test (a int, b int, c varchar) /* HINT: a (sum), a (avg), b (max) */---------- (3)

The data query statement may comprise one or more functions associated with one or more columns. An example data query statement is as given below in equation (4). The below data query statement comprises the function (avg) associated with the "col a".

SELECT AVG (a) FROM test WHERE b>100---------- (4)

The determination module **209** is configured to identify the presence of the function information in the data definition statement in equation (1). As an example, the determination module **209** identifies the presence of the function information "sum", "avg" and "max" for the "col a" and "col b" in the exemplary data definition statement given above.

The association module **211** is configured to associate the columns defined in the data definition statement with corresponding predefined functions based on the function information. The associated functions with the columns are stored in a memory **203**.

The comparison module is **213** configured to compare the functions in the data query statement with predefined functions associated to the one or more columns stored in the memory **203**

The accessing module **215** is configured to access the predefined functions associated with the one or more columns from the memory **203** for querying the database **107**.

The query optimization server **105** may also comprise other modules **217** to perform various miscellaneous functionalities of the query optimization server **105**. It will be appreciated that such aforementioned modules may be represented as a single module or a combination of different modules.

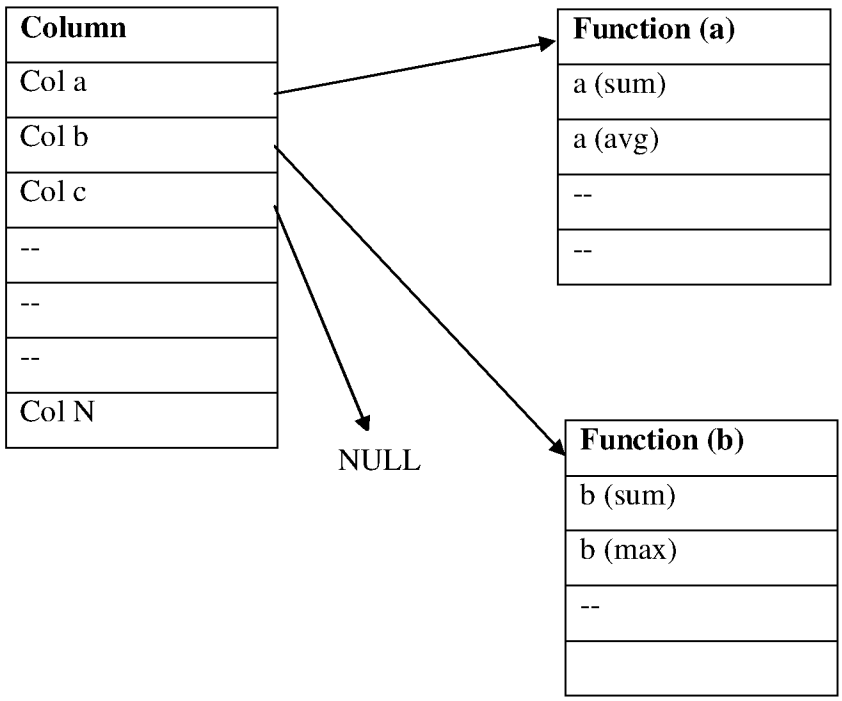
Figures 3a-3b shows an exemplary block diagram illustrating a method for optimizing query execution by association functions with columns in accordance with some embodiments of the present disclosure.

As shown in **figure 3a**, the user of the user device $\mathbf{101_1}$ defines a data definition statement as given below in equation (5) using Structured Query Language.

CREATE TABLE test (a int, b int, c varchar) /* HINT: a (sum), a (avg), b (max) */ ---------- (5)

The user device $\mathbf{101_1}$ transmits the data definition language to the query optimization server **105** through the communication network **103**. The receiving module **207** in the query optimization server **105** receives the data definition statement. Upon receiving the data definition statement, the query optimization server **105** creates a table namely "test" in the database **107**. The table "test" comprises of three columns namely "col a", "col b" and "col c". The "col a" and "col b" is of the integer type and the "col c" is of the variable character type. The determination module **209** identifies the presence of the function information i.e "HINT" in the data definition statement. The function information is provided for "col a" and "col b". Upon determining the presence of the function information, the association module **211** associates each of the columns having the function information with corresponding predefined functions based on the function information. For example, the functions "sum" and "avg" are associated with "col a" the function "max" is associated with "col b". As an example, a table namely "column" is stored in the memory **203** which comprises information of one or more columns provided in the data definition statement. The, "col a", "col b" and "col c" is stored in the table "column". Similarly, one or more tables are stored in the memory **203** which comprises predefined functions

associated with the columns. As an example, the table namely "function a" comprises one or more functions associated with "col a" and the table namely "function b" comprises one or more functions associated with "col b". The "col a" contains a pointer which includes address at which the corresponding predefined function is stored. Similarly, the "col b" contains a pointer which includes address at which the corresponding predefined function is stored. The "col c" does not contain the function information and therefore there is no association of the function for the "col c". Therefore, "col c" points to NULL. The association of the columns with the corresponding predefined functions is as shown below.

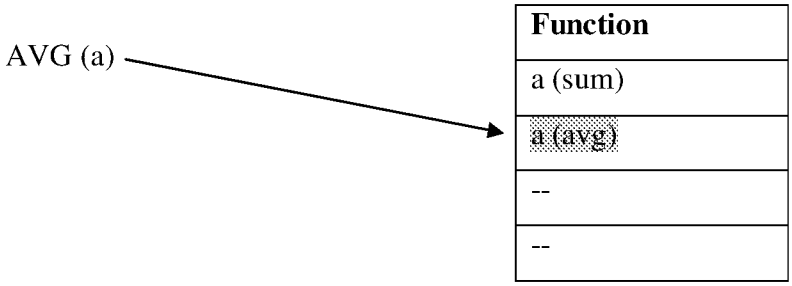


The "col a" contains a pointer for the function sum and avg. Similarly, the "col b" contains a pointer for the function max.

As shown in **figure 3b**, the user provides a data query statement for retrieving data from the database **107**. The receiving module **207** of the query optimization server **105** receives the data query statement from the user device $\mathbf{101_1}$ through the communication network **103**. Upon receiving the data query statement, the data optimization server **105** analyzes the data query statement for executing the data query statement. As an example, the data query statement received form the user device $\mathbf{101_1}$ is as given below in equation (6).

SELECT AVG (a) FROM test WHERE b>100. ---------- (6)

The data query statement is to retrieve the average of "col a" from the table "test" in the database **107** where the value of "col b" is greater than 100. The function (avg) is associated with "col a". The comparison module **213** compares the function (avg) associated with the "col a" with predefined functions stored in the memory **203** for "col a". The query optimization server **105** identifies that the function (avg) associated with "col a" matches with the predefined function stored in the memory **203** as shown below.



The accessing module **215** accesses the function (avg) from the memory **203** for executing the data query statement.

Figure 4a illustrates a flowchart showing method for associating functions with columns in accordance with some embodiments of the present disclosure.

As illustrated in **Figures 4a and 4b** the methods comprises one or more blocks for optimizing query execution by associating functions with columns. The methods may be described in the general context of computer executable instructions. Generally, computer executable instructions can include routines, programs, objects, components, data structures, procedures, modules, and functions, which perform particular functions or implement particular abstract data types.

The order in which the methods are described is not intended to be construed as a limitation, and any number of the described method blocks can be combined in any order to implement the methods. Additionally, individual blocks may be deleted from the methods **400,** without departing from the spirit and scope of the subject matter described herein. Furthermore,

the methods can be implemented in any suitable hardware, software, firmware, or combination thereof.

At **block 401**, a receiving module **207** receives a data definition statement. In an embodiment, the receiving module **207** of the query optimization server **105** receives a data definition statement from a user device **101**. The data definition statement comprises information of one or more columns for creating a table in a database **101**.

At **block 403**, a determination module **209** determines if the function information is present in the data definition statement. As an example, the function information may be provided for each column in the data definition statement. If the data definition statement includes the function information, then the method proceeds to **block 405** via "Yes". If the function information is not present in the data definition statement then the method proceeds to **block 411** via "No".

At **block 405**, a table is created in the database **107** comprising information of one or more columns having the function information. The query optimization server **105** creates a table in the memory **203.** The memory **203** comprises information of one or more columns having the function information. For example, if "col a" and "col b" has the function information, then "col a" and "col b" are stored in the table.

At **block 407**, a table is created in the database **107** comprising one or more predefined functions for one or more columns. The predefined functions are configured by the user in the memory **203**. The query optimization server **105** creates a table in the memory **203** which comprises one or more predefined functions for one or more columns. The predefined functions are configured based on the function information.

At **block 409,** an association module **211** associates the functions with column. The association module **211** associates the columns having the function information with the predefined functions based on the function information.

At **block 411**, the table defined in the data definition statement is created in the database **107**. The query optimization server **105** creates a table in the database **107** based on the column information defined in the data definition statement.

Figure 4b illustrates a flowchart showing method of accessing functions directly during run-time in accordance with some embodiments of the present disclosure.

At **block 413**, the receiving module **207** receives a data query statement. A user provides the data query statement for retrieving data from the database **107**. In an embodiment, the data query statement may comprise information of one or more functions associated with the columns.

At **block 415**, the comparison module **213** compares the one or more functions with predefined functions. The one or more functions associated with each column in the data query statement are compared with the predefined functions. If the one or more functions associated with each column match with the corresponding predefined functions then the method proceeds to **block 417** via **"Yes"**. If the one or more functions associated with each column do not match with the corresponding predefined functions then the method proceeds to **block 419** via "**No**".

At **block 417**, the accessing module **215** accesses the predefined function from the memory **203**. The query optimization server **105** determines the match between the function in the data query statement with the one or more predefined functions stored in the memory **203**. The accessing module **215** accesses the predefined function from the memory **203** for executing the data query statement during run time.

At **block 419**, the query optimization server **105** invokes the function manager which in turn calls respective mathematical function for executing the data query statement.

Computer System

Figure 5 illustrates a block diagram of an exemplary computer system **500** for implementing embodiments consistent with the present disclosure. In an embodiment, the computer system **500** is used to implement the query optimization server **105**. The computer system **500** optimizes query execution by associating functions with columns. The computer system **500** may comprise a central processing unit ("CPU" or "processor") **502**. The processor **502** may comprise at least one data processor for executing program components for executing user- or system-generated business processes. A user may include a person, a person using a device such as such as those included in this disclosure, or such a device itself. The processor

502 may include specialized processing units such as integrated system (bus) controllers, memory management control units, floating point units, graphics processing units, digital signal processing units, etc.

The processor **502** may be disposed in communication with one or more input/output (I/O) devices (**511** and **512**) via I/O interface **501**. The I/O interface **501** may employ communication protocols/methods such as, without limitation, audio, analog, digital, monoaural, RCA, stereo, IEEE-1394, serial bus, universal serial bus (USB), infrared, PS/2, BNC, coaxial, component, composite, digital visual interface (DVI), high-definition multimedia interface (HDMI), RF antennas, S-Video, VGA, IEEE 802.n /b/g/n/x, Bluetooth, cellular (e.g., code-division multiple access (CDMA), high-speed packet access (HSPA+), global system for mobile communications (GSM), long-term evolution (LTE), WiMax, or the like), etc.

Using the I/O interface **501**, the computer system **700** may communicate with one or more I/O devices (**511** and **512**). For example, the input device **511** may be an antenna, keyboard, mouse, joystick, (infrared) remote control, camera, card reader, fax machine, dongle, biometric reader, microphone, touch screen, touchpad, trackball, stylus, scanner, storage device, transceiver, video device/source, etc. The output device **512** may be a printer, fax machine, video display (e.g., Cathode Ray Tube (CRT), Liquid Crystal Display (LCD), Light-Emitting Diode (LED), plasma, Plasma Display Panel (PDP), Organic Light-Emitting Diode Display (OLED) or the like), audio speaker, etc.

In some embodiments, the processor **502** may be disposed in communication with a communication network **509** via a network interface **503**. The network interface **503** may communicate with the communication network **509**. The network interface **503** may employ connection protocols including, without limitation, direct connect, Ethernet (e.g., twisted pair 10/100/1000 Base T), Transmission Control Protocol/Internet Protocol (TCP/IP), token ring, IEEE 802.11a/b/g/n/x, etc. The communication network **509** may include, without limitation, a direct interconnection, Local Area Network (LAN), Wide Area Network (WAN), wireless network (e.g., using Wireless Application Protocol), the Internet, etc. Using the network interface **503** and the communication network **509**, the computer system **500** may communicate with data aggregator or sensors **510**.

In some embodiments, the processor **502** may be disposed in communication with a memory **505** (e.g., RAM, ROM, etc. not shown in **figure 5**) via a storage interface **504**. The storage interface **504** may connect to memory **505** including, without limitation, memory drives, removable disc drives, etc., employing connection protocols such as Serial Advanced Technology Attachment (SATA), Integrated Drive Electronics (IDE), IEEE-1394, Universal Serial Bus (USB), fiber channel, Small Computer Systems Interface (SCSI), etc. The memory drives may further include a drum, magnetic disc drive, magneto-optical drive, optical drive, Redundant Array of Independent Discs (RAID), solid-state memory devices, solid-state drives, etc.

The memory **505** may store a collection of program or database components, including, without limitation, user interface application **506**, an operating system **507**, web server **508** etc. In some embodiments, computer system **500** may store user/application data **506**, such as the data, variables, records, etc. as described in this disclosure. Such databases may be implemented as fault-tolerant, relational, scalable, secure databases such as Oracle or Sybase.

The operating system **507** may facilitate resource management and operation of the computer system **500**. Examples of operating systems include, without limitation, Apple Macintosh OS X, Unix, Unix-like system distributions (e.g., Berkeley Software Distribution (BSD), FreeBSD, NetBSD, OpenBSD, etc.), Linux distributions (e.g., Red Hat, Ubuntu, Kubuntu, etc.), IBM OS/2, Microsoft Windows (XP, Vista/7/8, etc.), Apple iOS, Google Android, Blackberry OS, or the like. User interface **517** may facilitate display, execution, interaction, manipulation, or operation of program components through textual or graphical facilities. For example, user interfaces may provide computer interaction interface elements on a display system operatively connected to the computer system **500**, such as cursors, icons, check boxes, menus, scrollers, windows, widgets, etc. Graphical User Interfaces (GUIs) may be employed, including, without limitation, Apple Macintosh operating systems' Aqua, IBM OS/2, Microsoft Windows (e.g., Aero, Metro, etc.), Unix X-Windows, web interface libraries (e.g., ActiveX, Java, Javascript, AJAX, HTML, Adobe Flash, etc.), or the like.

In some embodiments, the computer system **500** may implement a web browser **508** stored program component. The web browser may be a hypertext viewing application, such as Microsoft Internet Explorer, Google Chrome, Mozilla Firefox, Apple Safari, etc. Secure web

browsing may be provided using Secure Hypertext Transport Protocol (HTTPS), Secure Sockets Layer (SSL), Transport Layer Security (TLS), etc. Web browsers may utilize facilities such as AJAX, DHTML, Adobe Flash, JavaScript, Java, Application Programming Interfaces (APIs), etc. In some embodiments, the computer system **500** may implement a mail server **519** stored program component. The mail server may be an Internet mail server such as Microsoft Exchange, or the like. The mail server may utilize facilities such as ASP, ActiveX, ANSI C++/C#, Microsoft .NET, CGI scripts, Java, JavaScript, PERL, PHP, Python, WebObjects, etc. The mail server may utilize communication protocols such as Internet Message Access Protocol (IMAP), Messaging Application Programming Interface (MAPI), Microsoft Exchange, Post Office Protocol (POP), Simple Mail Transfer Protocol (SMTP), or the like. In some embodiments, the computer system **700** may implement a mail client stored program component. The mail client may be a mail viewing application, such as Apple Mail, Microsoft Entourage, Microsoft Outlook, Mozilla Thunderbird, etc.

Furthermore, one or more computer-readable storage media may be utilized in implementing embodiments consistent with the present disclosure. A computer-readable storage medium refers to any type of physical memory on which information or data readable by a processor may be stored. Thus, a computer-readable storage medium may store instructions for execution by one or more processors, including instructions for causing the processor(s) to perform steps or stages consistent with the embodiments described herein. The term "computer-readable medium" should be understood to include tangible items and exclude carrier waves and transient signals, i.e., non-transitory. Examples include Random Access Memory (RAM), Read-Only Memory (ROM), volatile memory, nonvolatile memory, hard drives, CD ROMs, DVDs, flash drives, disks, and any other known physical storage media.

Additionally, advantages of present disclosure are illustrated herein.

Embodiments of the present disclosure help the user to define the one or more function information for each column in the data definition statement.

Embodiments of the present disclosure reduce the overhead of the function manager to call the respective functions at run time execution of the query.

Embodiments of the present disclosure provide predefined functions for various columns of the table. Therefore, the functions can be accessed directly during run time using column identification.

The present disclosure avoids generation of huge set of precompiled functions.

The present disclosure optimizes query execution by saving time.

The described operations may be implemented as a method, system or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware, or any combination thereof. The described operations may be implemented as code maintained in a "non-transitory computer readable medium", where a processor may read and execute the code from the computer readable medium. The processor is at least one of a microprocessor and a processor capable of processing and executing the queries. A non-transitory computer readable medium may comprise media such as magnetic storage medium (e.g., hard disk drives, floppy disks, tape, etc.), optical storage (CD-ROMs, DVDs, optical disks, etc.), volatile and non-volatile memory devices (e.g., EEPROMs, ROMs, PROMs, RAMs, DRAMs, SRAMs, Flash Memory, firmware, programmable logic, etc.), etc. Further, non-transitory computer-readable media comprise all computer-readable media except for a transitory. The code implementing the described operations may further be implemented in hardware logic (e.g., an integrated circuit chip, Programmable Gate Array (PGA), Application Specific Integrated Circuit (ASIC), etc.).

Still further, the code implementing the described operations may be implemented in "transmission signals", where transmission signals may propagate through space or through a transmission media, such as an optical fiber, copper wire, etc. The transmission signals in which the code or logic is encoded may further comprise a wireless signal, satellite transmission, radio waves, infrared signals, Bluetooth, etc. The transmission signals in which the code or logic is encoded is capable of being transmitted by a transmitting station and received by a receiving station, where the code or logic encoded in the transmission signal may be decoded and stored in hardware or a non-transitory computer readable medium at the receiving and transmitting stations or devices. An "article of manufacture" comprises non-transitory computer readable medium, hardware logic, and/or transmission signals in which code may be implemented. A

device in which the code implementing the described embodiments of operations is encoded may comprise a computer readable medium or hardware logic. Of course, those skilled in the art will recognize that many modifications may be made to this configuration without departing from the scope of the disclosure, and that the article of manufacture may comprise suitable information bearing medium known in the art.

The terms "an embodiment", "embodiment", "embodiments", "the embodiment", "the embodiments", "one or more embodiments", "some embodiments", and "one embodiment" mean "one or more (but not all) embodiments of the disclosure(s)" unless expressly specified otherwise.

The terms "including", "comprising", “having” and variations thereof mean "including but not limited to", unless expressly specified otherwise.

The enumerated listing of items does not imply that any or all of the items are mutually exclusive, unless expressly specified otherwise.

The terms "a", "an" and "the" mean "one or more", unless expressly specified otherwise.

A description of an embodiment with several components in communication with each other does not imply that all such components are required. On the contrary a variety of optional components are described to illustrate the wide variety of possible embodiments of the disclosure.

When a single device or article is described herein, it will be readily apparent that more than one device/article (whether or not they cooperate) may be used in place of a single device/article. Similarly, where more than one device or article is described herein (whether or not they cooperate), it will be readily apparent that a single device/article may be used in place of the more than one device or article or a different number of devices/articles may be used instead of the shown number of devices or programs. The functionality and/or the features of a device may be alternatively embodied by one or more other devices which are not explicitly described as having such functionality/features. Thus, other embodiments of the disclosure need not include the device itself.

The illustrated operations of **Figures 4a and 4b** show certain events occurring in a certain order. In alternative embodiments, certain operations may be performed in a different

order, modified or removed. Moreover, steps may be added to the above described logic and still conform to the described embodiments. Further, operations described herein may occur sequentially or certain operations may be processed in parallel. Yet further, operations may be performed by a single processing unit or by distributed processing units.

Finally, the language used in the specification has been principally selected for readability and instructional purposes, and it may not have been selected to delineate or circumscribe the inventive subject matter. It is therefore intended that the scope of the disclosure be limited not by this detailed description, but rather by any claims that issue on an application based here on. Accordingly, the embodiments of the present disclosure are intended to be illustrative, but not limiting, of the scope of the disclosure, which is set forth in the following claims.

While various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

We claim:

1. A method of associating functions with columns for optimizing query execution, the method comprising:

receiving, by a query optimization server, a definition statement comprising information of one or more columns for creating a table;

determining, by the query optimization server, presence of one or more function information for each of the one or more columns in the definition statement; and

associating, by the query optimization server, each of the one or more columns having the one or more function information with corresponding predefined functions, for optimizing the query execution.

2. The method as claimed in claim 1, wherein the one or more columns and the corresponding predefined functions are stored in a memory.

3. The method as claimed in claim 1 further comprising:

receiving, by the query optimization server, a query statement comprising one or more functions associated with one or more columns, for querying a database;

comparing, by the query optimization server, the one or more functions associated with the one or more columns with predefined functions associated to the one or more columns in the memory; and

accessing, by the query optimization server, the predefined function associated to the one or more columns from the memory based on the comparison, for execution of the query statement.

4. The method as claimed in claim 1, wherein the one or more function information are provided by a user in the definition statement.

5. A query optimization server for associating functions with columns for optimizing query execution, comprising:

a receiving module for receiving a definition statement comprising information of one or more columns for creating a table from one or more client devices;

a determination module for determining presence of one or more function information for each of the one or more columns in the definition statement; and

an association module for associating each of the one or more columns having the one or more function information with corresponding predefined functions for optimizing the query execution.

6. The query optimization server as claimed in claim 5 stores the one or more columns and the corresponding predefined functions in a memory.

7. The query optimization server as claimed in claim 5, wherein the one or more function information are provided by a user in the definition statement.

8. The query optimization server as claimed in claim 5, wherein the receiving module is further configured to receive a query statement, comprising one or more functions associated with one or more columns, from the one or more client devices for querying the database.

9. The query optimization server as claimed in claim 8 further comprises:

a comparison module for comparing the one or more functions associated with the one or more columns with predefined functions associated to the one or more columns in the memory; and

an accessing module for accessing the predefined function associated with the one or more columns from the memory based on the comparison, for execution of the one or more query statements.

10. A non-transitory computer readable medium including operations stored thereon that when processed by at least one processing unit cause a query optimization server to perform one or more actions by performing the acts of:

receiving a definition statement comprising information of one or more columns for creating a table;

determining presence of one or more function information for each of the one or more columns in the definition statement; and

associating each of the one or more columns having the one or more function information with corresponding predefined functions, for optimizing the query execution.

11. The medium as claimed in claim 10, wherein the instructions further cause the at least one processing unit to perform one or more actions by performing the acts of:

receiving a query statement comprising one or more functions associated with one or more columns, for querying a database;

comparing the one or more functions associated with the one or more columns with predefined functions associated to the one or more columns in the memory; and

accessing the predefined function associated with the one or more columns from the memory based on the comparison for execution of the query statement.

12. A computer program for performing one or more actions on a query optimization server, said computer program comprising code segment for receiving a definition statement comprising information of one or more columns for creating a table; code segment for determining presence of one or more function information for each of the one or more columns in the definition statement; and code segment for associating each of the one or more columns having the one or more function information with corresponding predefined functions, for optimizing the query execution.

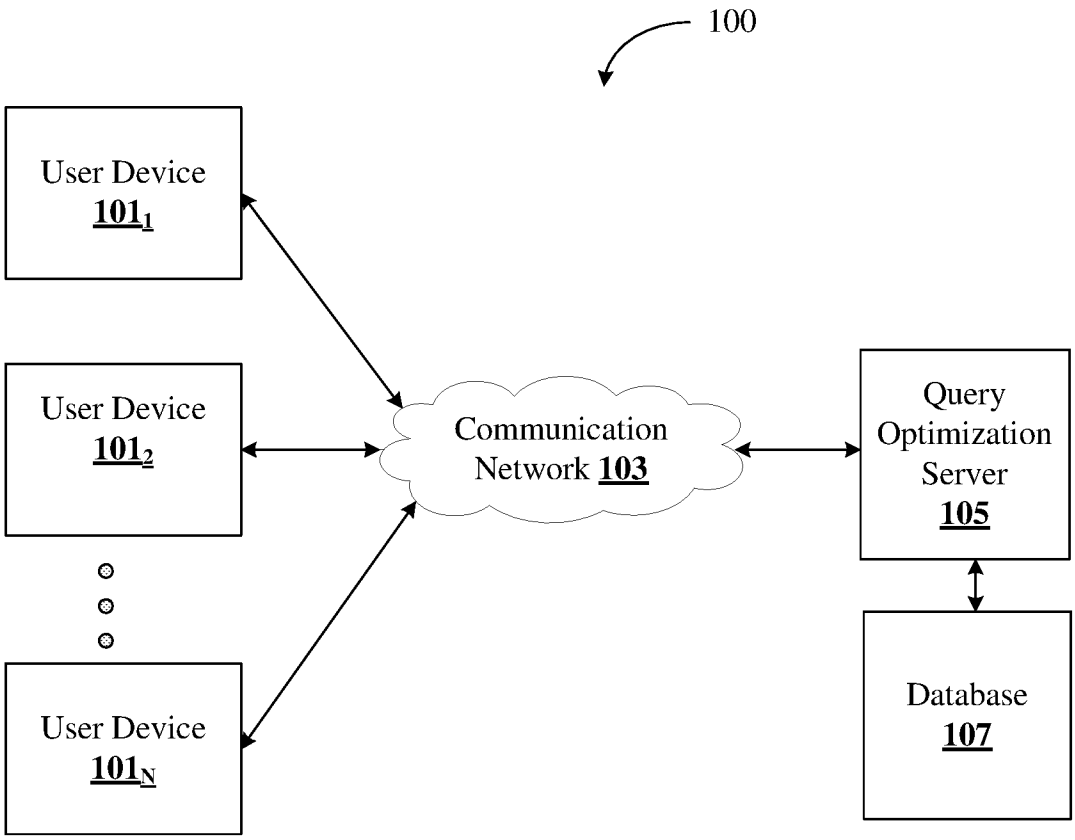

100
User Device
101₁
User Device
101₂
User Device
101N
Communication
Network 103
Query
Optimization
Server
105
Database
107

Fig.1

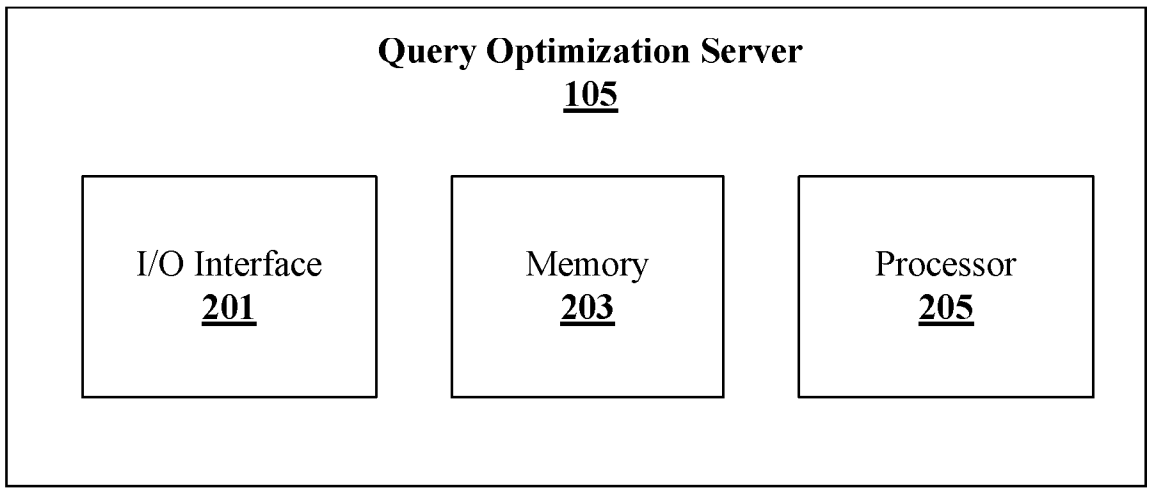

Query Optimization Server
105
I/O Interface
201
Memory
203
Processor
205

Fig.2a

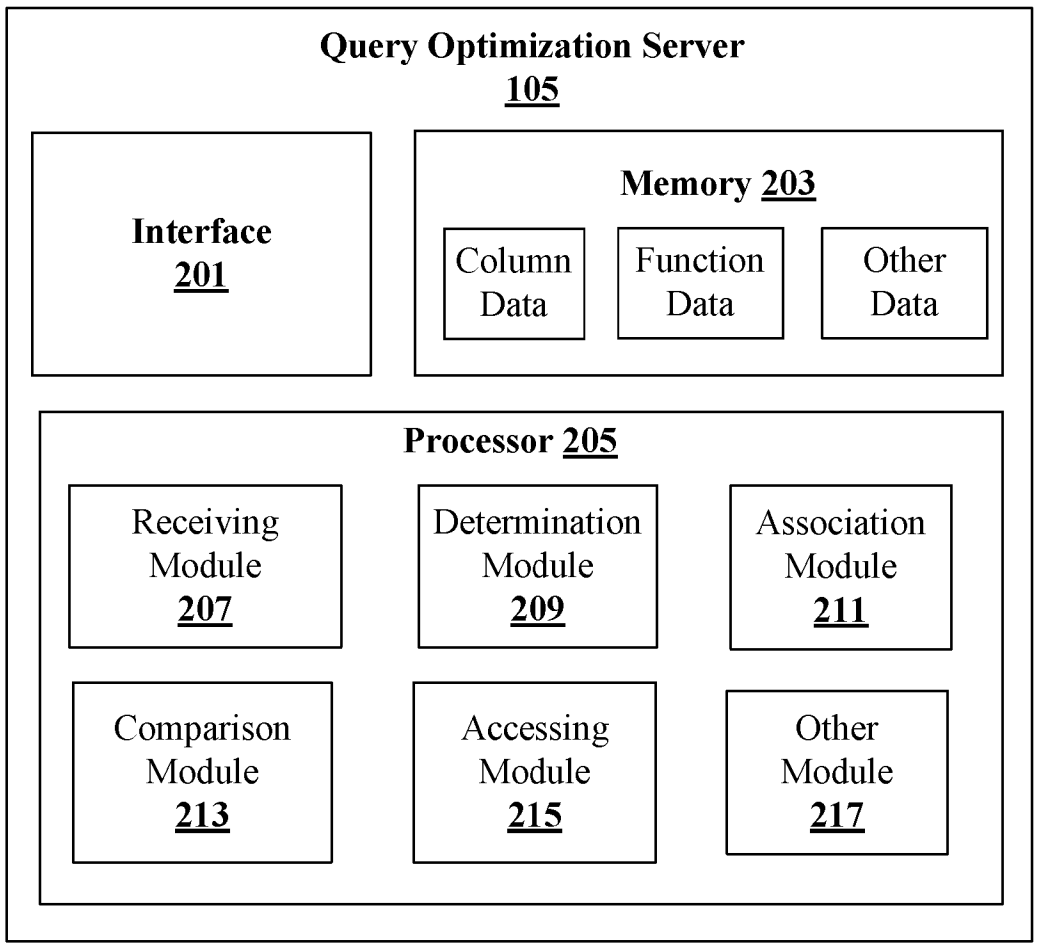

Query Optimization Server
105
Interface
201
Memory 203
Column Data
Function Data
Other Data
Processor 205
Receiving Module
207
Determination Module
209
Association Module
211
Comparison Module
213
Accessing Module
215
Other Module
217

Fig.2b

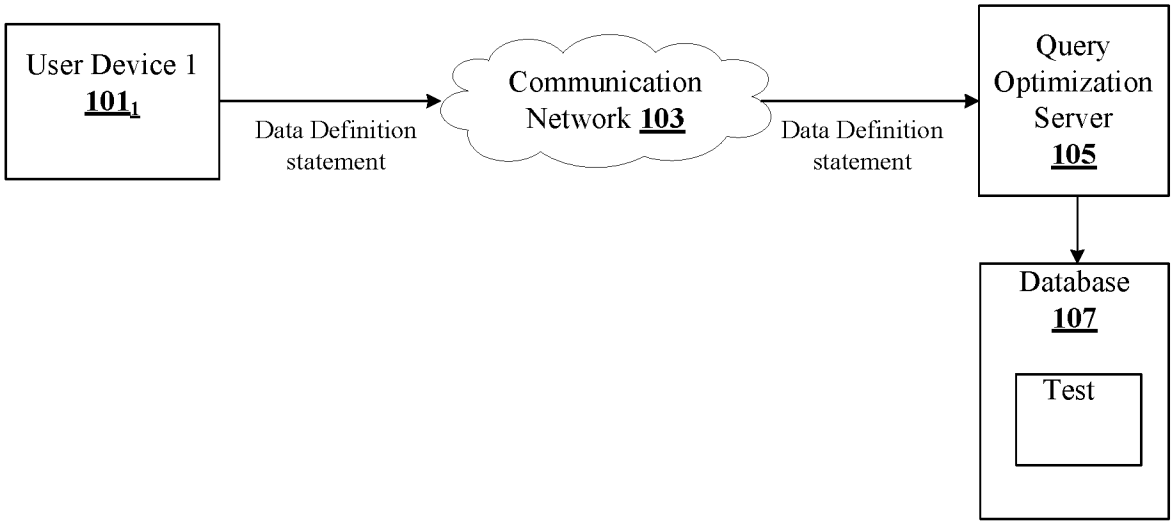

User Device 1
101₁
Data Definition statement
Communication Network 103
Data Definition statement
Query Optimization Server 105
Database 107
Test

Fig.3a

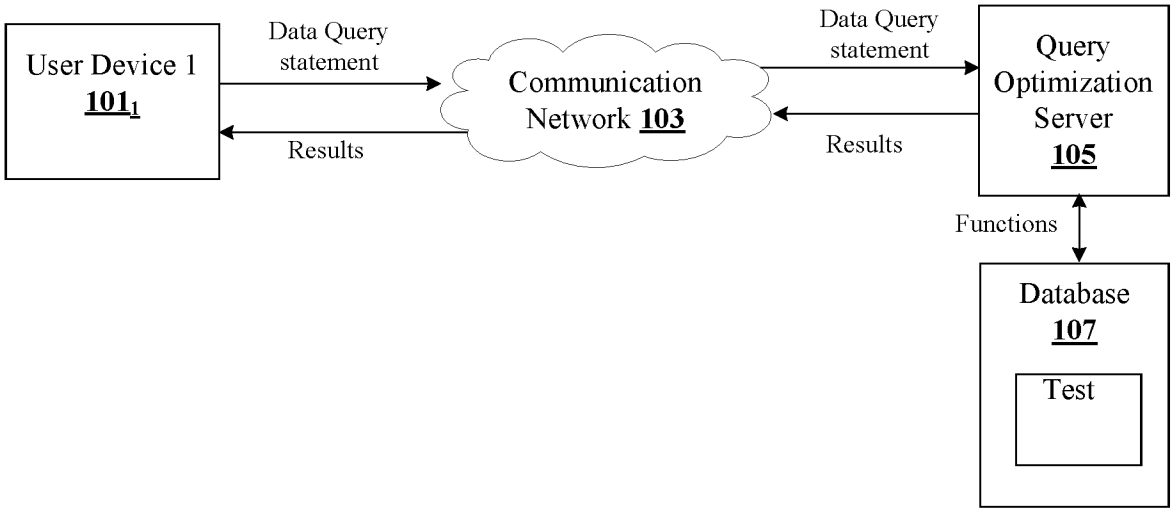

User Device 1
101₁
Data Query statement
Results
Communication Network 103
Data Query statement
Results
Query Optimization Server 105
Functions
Database 107
Test

Fig.3b

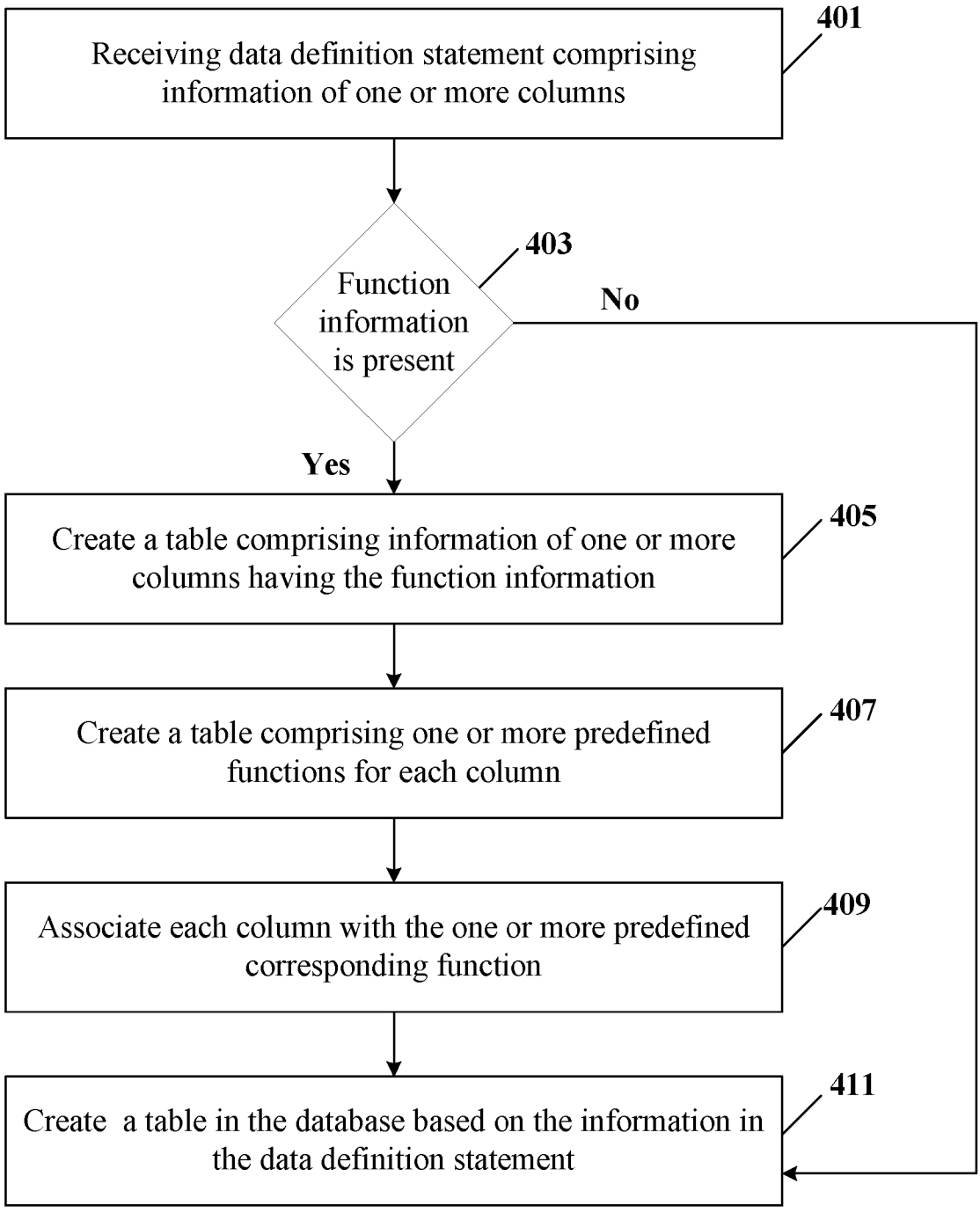

Receiving data definition statement comprising information of one or more columns
401
Function information is present
403
No
Yes
Create a table comprising information of one or more columns having the function information
405
Create a table comprising one or more predefined functions for each column
407
Associate each column with the one or more predefined corresponding function
409
Create a table in the database based on the information in the data definition statement
411

Fig.4a

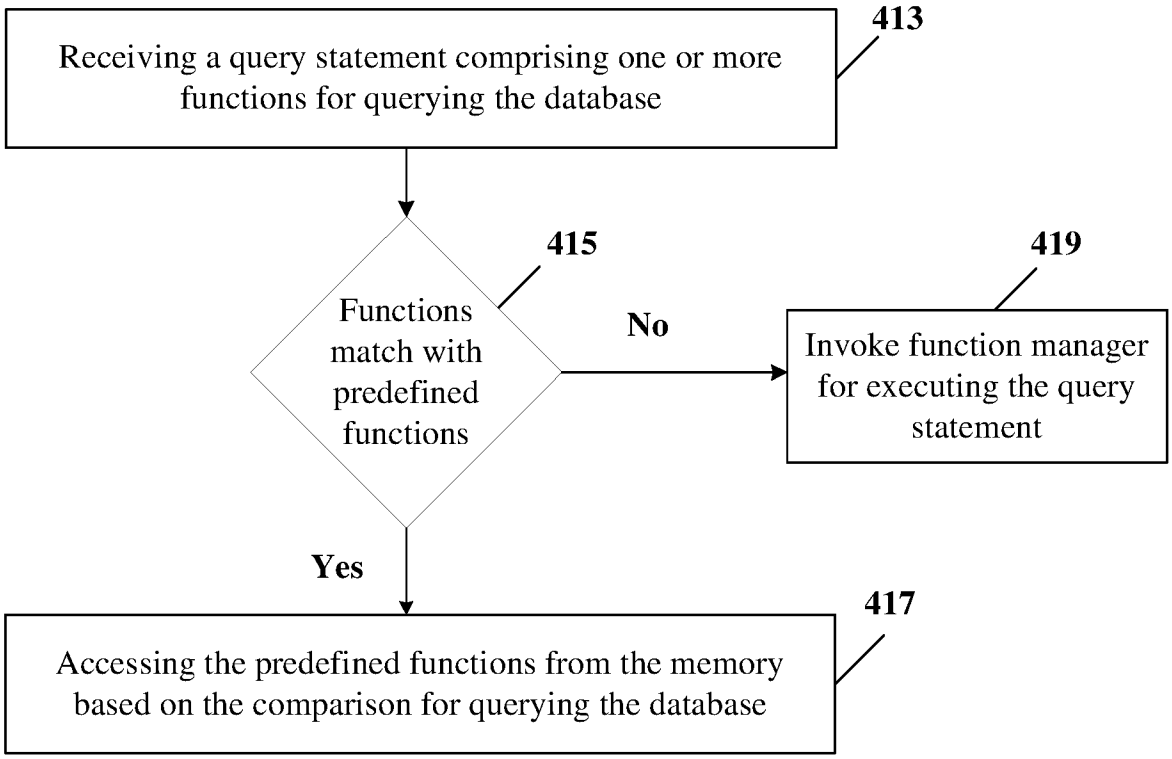

Receiving a query statement comprising one or more functions for querying the database
413
Functions match with predefined functions
415
No
Invoke function manager for executing the query statement
419
Yes
Accessing the predefined functions from the memory based on the comparison for querying the database
417

Fig.4b

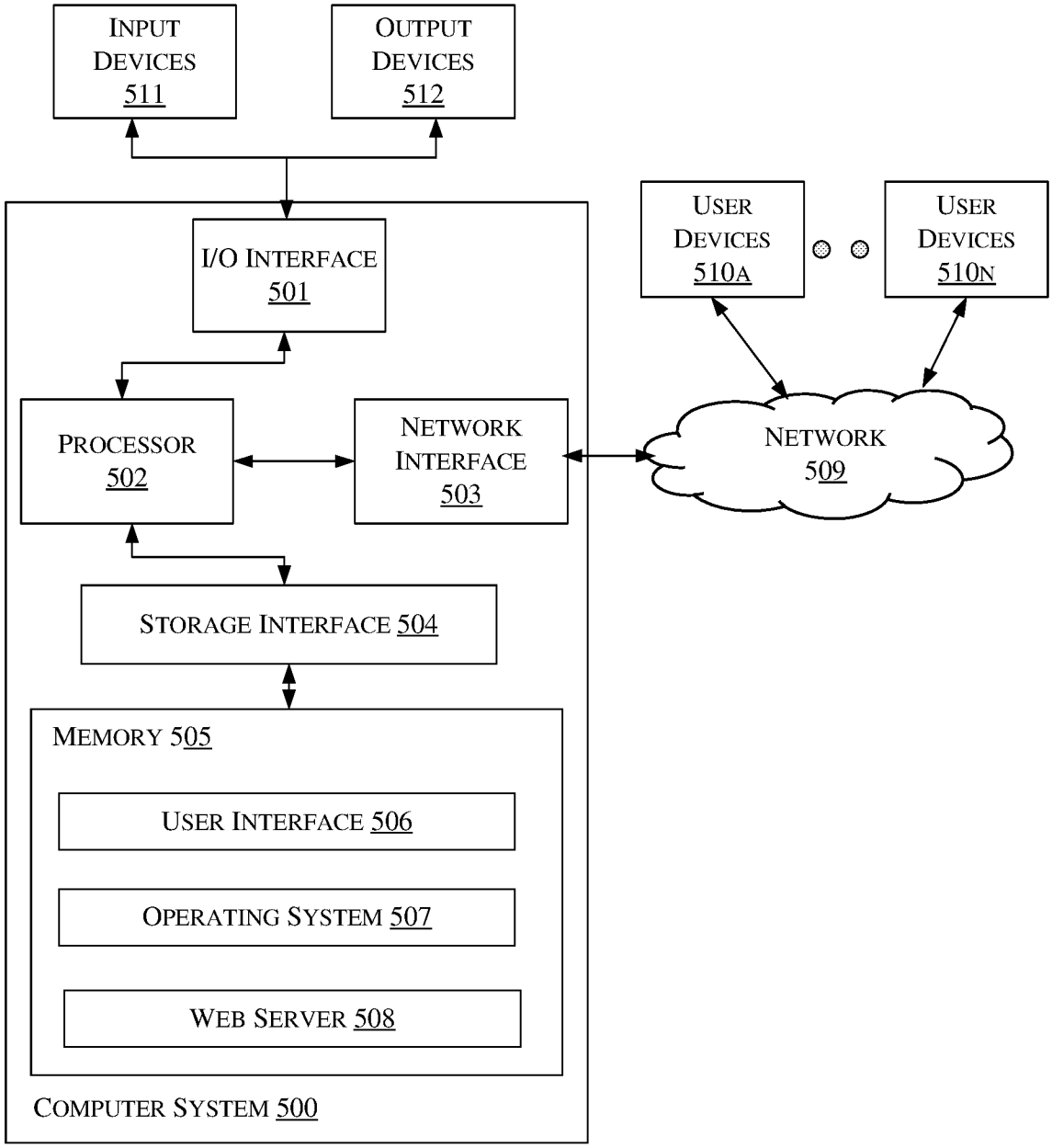

INPUT DEVICES 511
OUTPUT DEVICES 512
I/O INTERFACE 501
PROCESSOR 502
NETWORK INTERFACE 503
STORAGE INTERFACE 504
MEMORY 505
USER INTERFACE 506
OPERATING SYSTEM 507
WEB SERVER 508
COMPUTER SYSTEM 500
USER DEVICES 510A
USER DEVICES 510N
NETWORK 509

Fig.5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/073135

A. CLASSIFICATION OF SUBJECT MATTER

G06F 17/30(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT,CNKI,WPI,EPODOC: database, table, query, search, create,definiton,predefine,column,function,identification, compare,associate,optimize

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 103902543 A (HUAWEI TECHNOLOGIES CO., LTD. ET AL.) 02 July 2014 (2014-07-02) description, paragraphs [0051]-[0078]	1-12
A	CN 103226610 A (HUAWEI TECHNOLOGIES CO., LTD.) 31 July 2013 (2013-07-31) the whole document	1-12
A	CN 103177057 A (SAP AG) 26 June 2013 (2013-06-26) the whole document	1-12
A	US 2006167850 A1 (INTERNATIONAL BUSINESS MACHINES CORPORATION) 27 July 2006 (2006-07-27) the whole document	1-12
A	US 2009177621 A1 (LE, JIAN ET AL.) 09 July 2009 (2009-07-09) the whole document	1-12

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 April 2016	**09 May 2016**

Name and mailing address of the ISA/CN	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/073135

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	103902543	A	02 July 2014	None			
CN	103226610	A	31 July 2013	None			
CN	103177057	A	26 June 2013	US	2013159285	A1	20 June 2013
				US	2015095309	A1	02 April 2015
				EP	2608066	A2	26 June 2013
US	2006167850	A1	27 July 2006	US	2013046774	A1	21 February 2013
US	2009177621	A1	09 July 2009	None			